



US012609438B2

(12) **United States Patent**
Cai et al.

(10) **Patent No.:** **US 12,609,438 B2**
(45) **Date of Patent:** **Apr. 21, 2026**

(54) **FOLDABLE ELECTRONIC DEVICE**

(71) Applicant: **HONOR DEVICE CO., LTD.**,
Shenzhen (CN)

(72) Inventors: **Xiaotao Cai**, Shenzhen (CN); **Dawei Zhou**, Shenzhen (CN); **Tiezhu Liang**,
Shenzhen (CN)

(73) Assignee: **HONOR DEVICE CO., LTD.**,
Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 206 days.

(21) Appl. No.: **18/561,807**

(22) PCT Filed: **Feb. 2, 2023**

(86) PCT No.: **PCT/CN2023/074290**

§ 371 (c)(1),

(2) Date: **Nov. 17, 2023**

(87) PCT Pub. No.: **WO2024/060479**

PCT Pub. Date: **Mar. 28, 2024**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 21, 2022 (CN) 202211150514.6

(51) **Int. Cl.**

H01Q 1/22 (2006.01)

H01Q 19/22 (2006.01)

(52) **U.S. Cl.**

CPC **H01Q 1/2266** (2013.01); **H01Q 19/22**
(2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56)

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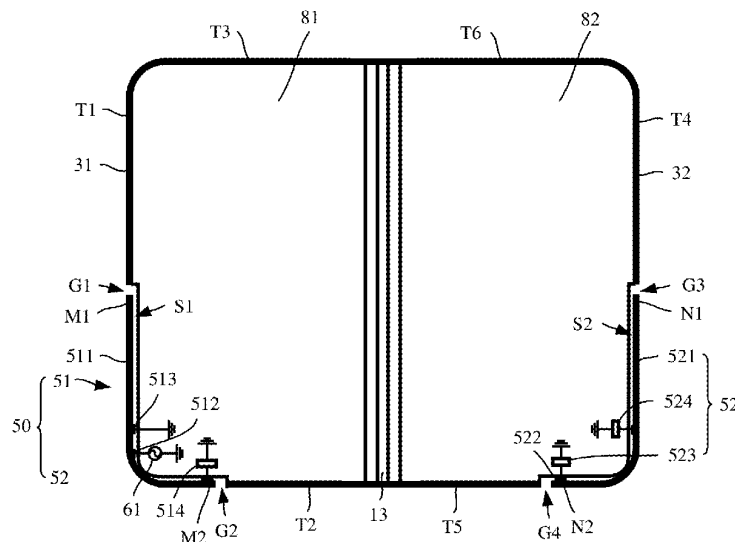
Primary Examiner — Crystal L Hammond

(57)

ABSTRACT

This application provides a foldable electronic device, including two main bodies that are capable of being relatively folded or unfolded and a main antenna unit and a parasitic antenna unit that are respectively disposed on the two main bodies. The main antenna unit includes a radiation stub and a ground port disposed between two ends of the radiation stub. The parasitic antenna unit includes a parasitic stub and a ground return port, and the ground return port is disposed on the parasitic stub and is close to or located at one of end portions of the parasitic stub. When the electronic device is in a folded state, the parasitic stub overlaps the radiation stub.

18 Claims, 26 Drawing Sheets





US012609448B2

(12) **United States Patent**
Li et al.

(10) **Patent No.:** **US 12,609,448 B2**
(45) **Date of Patent:** **Apr. 21, 2026**

(54) **COLLOCATED MMWAVE AND SUB-6 GHZ ANTENNAS**

(71) Applicant: **Google LLC**, Mountain View, CA (US)

(72) Inventors: **Pei Li**, Milpitas, CA (US); **Chun Kit Lai**, Sunnyvale, CA (US); **Vijay L. Asrani**, San Jose, CA (US)

(73) Assignee: **Google LLC**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 336 days.

(21) Appl. No.: **18/247,601**

(22) PCT Filed: **Aug. 31, 2021**

(86) PCT No.: **PCT/US2021/048452**

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(2) Date: **Mar. 31, 2023**

(87) PCT Pub. No.: **WO2022/072105**

PCT Pub. Date: **Apr. 7, 2022**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Provisional application No. 63/086,480, filed on Oct. 1, 2020.

(51) **Int. Cl.**
H01Q 5/307 (2015.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/307** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/40** (2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/307; H01Q 1/243; H01Q 5/40; H01Q 21/28; H01Q 5/392

See application file for complete search history.

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Primary Examiner — Dameon E Levi

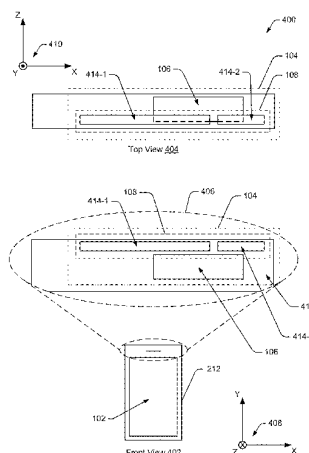
Assistant Examiner — Jordan E. DeWitt

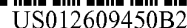
(74) *Attorney, Agent, or Firm* — Colby Nipper PLLC

(57) **ABSTRACT**

Techniques and apparatuses are described that implement collocated mm Wave and sub-6 GHz antennas. An apparatus includes at least one mmWave antenna that produces a near-field radiation region and a far-field radiation pattern in a mmWave frequency band. Disposed within the near-field radiation region is a sub-6 GHz antenna that produces a radiation pattern in a sub-6 GHz frequency band. The sub 6 GHz antenna is able to positively affect the far-field radiation pattern from the mm Wave antenna (e.g., via steering and/or broadening). In this way, the mmWave antenna and the sub-6 GHz antenna can be collocated to conserve space while also steering and/or broadening the far-field radiation pattern of the mm Wave antenna.

20 Claims, 7 Drawing Sheets





(10) **Patent No.:** US 12,609,450 B2
(45) **Date of Patent:** Apr. 21, 2026

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Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Bamidele A Immanuel

(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna system includes a first antenna structure which includes a first ground element, a first radiation element, a second radiation element, and a third radiation element. The first radiation element is coupled to the first ground element. A region is defined by the first ground element and the first radiation element. The second radiation element has a first feeding point. The second radiation element is adjacent to the first radiation element. The third radiation element is coupled to the first feeding point. The third radiation element is adjacent to the first ground element. The second radiation element and the third radiation element are disposed inside the aforementioned region.

17 Claims, 8 Drawing Sheets

(58) **Field of Classification Search**
CPC H01Q 9/0421; H01Q 1/48; H01Q 5/30;
H01Q 1/243; H01Q 9/42; H01Q 5/371
See application file for complete search history.



US012609456B2

(12) **United States Patent**
Hsiao

(10) **Patent No.:** **US 12,609,456 B2**
(45) **Date of Patent:** **Apr. 21, 2026**

(54) **SLOT ANTENNA STRUCTURE AND SLOT ANTENNA DEVICE INCLUDING THE SAME**

(71) Applicant: **Microwave Information Technology Ltd.**, Hsinchu City (TW)

(72) Inventor: **Yu-Ting Hsiao**, Hsinchu City (TW)

(73) Assignee: **Microwave Information Technology Ltd.**, Hsinchu City (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 194 days.

(21) Appl. No.: **18/456,376**

(22) Filed: **Aug. 25, 2023**

(65) **Prior Publication Data**

US 2024/0178572 A1 May 30, 2024

(30) **Foreign Application Priority Data**

Nov. 24, 2022 (TW) 111145034

(51) **Int. Cl.**
H01Q 13/18 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/18** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/18
See application file for complete search history.

(56) **References Cited**

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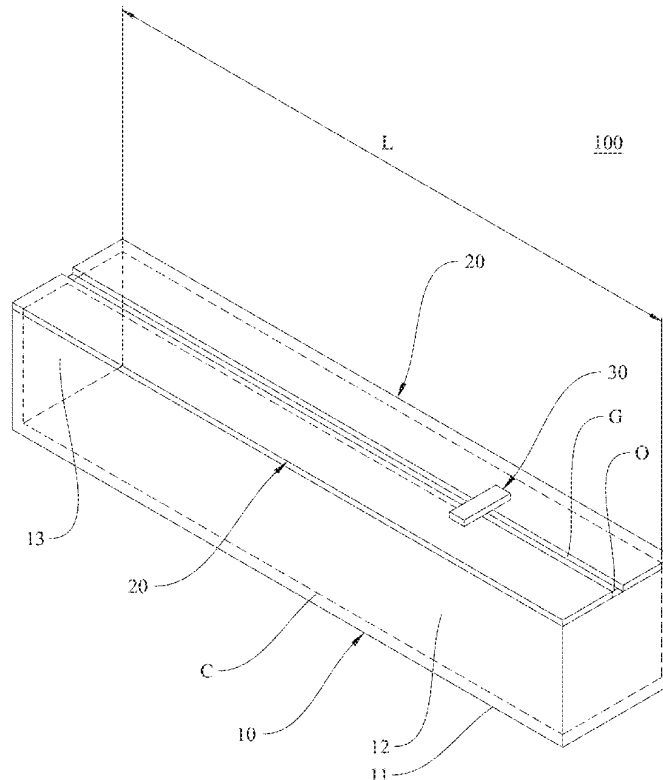
Primary Examiner — Robert Karacsony

(74) *Attorney, Agent, or Firm* — Muncy, Geissler, Olds & Lowe, P.C.

(57) **ABSTRACT**

A slot antenna structure includes a metal trough and two metal plates. The metal trough includes a metal bottom plate, two metal sidewalls erected on two opposite long sides of the metal bottom plate respectively, two metal closing walls erected on two opposite short sides of the metal bottom plate respectively, and an opening formed and surrounded by the metal sidewalls and the metal closing walls. The metal plates are provided on the opening. A slot is formed between the metal plates and extends in a straight line to separate the metal plates. An electrical unit is provided on the metal plates and astride the slot. The metal plates and the metal trough form a resonance chamber in communication with the slot. The depth from the opening to the inner bottom side of the metal trough is generally one eighth of the wavelength of an input signal.

10 Claims, 5 Drawing Sheets





US012609457B2

(12) **United States Patent**
Tang

(10) **Patent No.:** **US 12,609,457 B2**
(45) **Date of Patent:** **Apr. 21, 2026**

(54) **ANTENNA**

(71) Applicant: **LINQ ANTENNA TECHNOLOGY INC.**, La Puente, CA (US)

(72) Inventor: **Hong Tang**, Foshan (CN)

(73) Assignee: **LINQ ANTENNA TECHNOLOGY INC.**, La Puente, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 300 days.

(21) Appl. No.: **18/379,414**

(22) Filed: **Oct. 12, 2023**

(65) **Prior Publication Data**

US 2024/0413540 A1 Dec. 12, 2024

Related U.S. Application Data

(63) Continuation-in-part of application No. PCT/CN2023/101872, filed on Jun. 21, 2023.

(30) **Foreign Application Priority Data**

Jun. 8, 2023 (CN) 202310677770.9

(51) **Int. Cl.**
H01Q 13/20 (2006.01)
H01Q 1/38 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/20** (2013.01); **H01Q 1/50** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/064; H01Q 13/18; H01Q 21/005; H01Q 1/38; H01Q 1/48; H01Q 13/10;
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(56) **References Cited**

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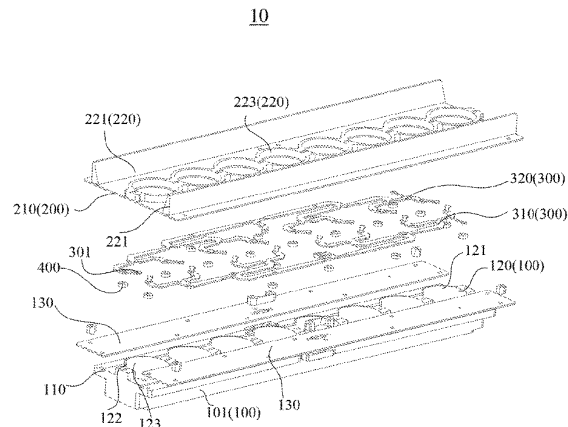
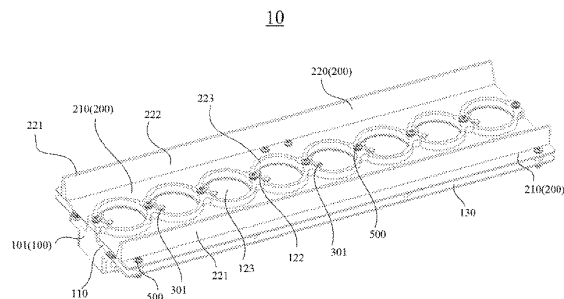
Primary Examiner — Wei (Victor) Y Chan

(74) *Attorney, Agent, or Firm* — Dicke, Billig & Czaja, PLLC

(57) **ABSTRACT**

Provided is an antenna, which integrates a waveguide structure and an ordinary feeding network, thereby avoiding a complex structure. The antenna can be used as a base station antenna and wifi antenna. The antenna includes: a waveguide radiator, including a lower radiation panel and at least one waveguide structure provided on the lower radiation panel; an upper-layer radiator, including an upper radiation panel, wherein the upper radiation panel is provided with at least one opening, and the opening is corresponding to the waveguide structure one by one; and a feeding network, connected to each waveguide structure, wherein at least a part of the feeding network is provided between the lower radiation panel and the upper radiation panel, and has a gap with the lower radiation panel and the upper radiation panel, respectively.

18 Claims, 5 Drawing Sheets





US012609726B2

(12) **United States Patent**
Raghavan et al.

(10) **Patent No.:** **US 12,609,726 B2**
(45) **Date of Patent:** **Apr. 21, 2026**

(54) **ANTENNA SIDE COMBINING OR ANTENNA SIDE SELECTION IN AN L-SHAPED ANTENNA MODULE**

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)
(72) Inventors: **Vasanthan Raghavan**, West Windsor Township, NJ (US); **Mohammad Ali Tassoudji**, San Diego, CA (US); **Raghu Narayan Challa**, San Diego, CA (US); **Tao Luo**, San Diego, CA (US); **Junyi Li**, Fairless Hills, PA (US)

(73) Assignee: **QUALCOMM Incorporated**, San Diego, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 478 days.

(21) Appl. No.: **17/812,331**

(22) Filed: **Jul. 13, 2022**

(65) **Prior Publication Data**
US 2024/0022281 A1 Jan. 18, 2024

(51) **Int. Cl.**
H04B 1/401 (2015.01)
H04B 7/06 (2006.01)
H04B 7/08 (2006.01)

(52) **U.S. Cl.**
CPC **H04B 1/401** (2013.01); **H04B 7/0686** (2013.01); **H04B 7/0842** (2013.01)

(58) **Field of Classification Search**
CPC H04B 1/401; H04B 7/0686; H04B 7/0842; H04B 7/0469; H04B 7/0874; H04B 7/10; H04B 7/0691; H01Q 1/243; H01Q 3/24; H01Q 21/0025; H01Q 21/06
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Lana N Le

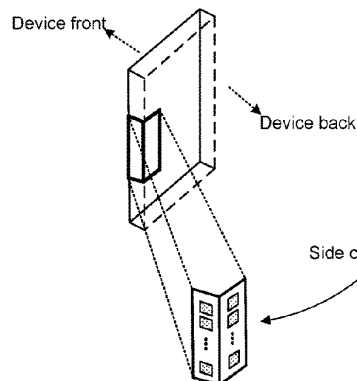
(74) *Attorney, Agent, or Firm* — Harrity & Harrity, LLP

(57) **ABSTRACT**

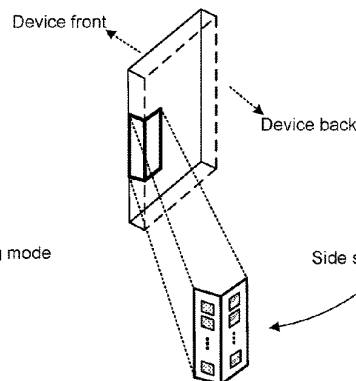
Various aspects of the present disclosure generally relate to wireless communication. In some aspects, a user equipment (UE) may determine a target mode in which to operate an L-shaped antenna module that includes a first antenna subarray on a first side of the L-shaped antenna module and a second antenna subarray on a second side of the L-shaped antenna module. The UE may configure the L-shaped antenna module to operate in the target mode. Numerous other aspects are described.

30 Claims, 9 Drawing Sheets

500 →



510
Side combining mode



520
Side selection mode

□ Active antenna element
□ Inactive antenna element



US012614834B2

(12) **United States Patent**
Lu et al.

(10) **Patent No.:** **US 12,614,834 B2**
(45) **Date of Patent:** **Apr. 28, 2026**

(54) **ANTENNA STRUCTURE AND ELECTRONIC DEVICE**

(71) Applicant: **JRD COMMUNICATION (SHENZHEN) LTD.**, Shenzhen (CN)

(72) Inventors: **Zhengkun Lu**, Shenzhen (CN);
Xinrong An, Shenzhen (CN)

(73) Assignee: **JRD COMMUNICATION (SHENZHEN) LTD.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 391 days.

(21) Appl. No.: **18/255,505**

(22) PCT Filed: **Dec. 14, 2020**

(86) PCT No.: **PCT/CN2020/136013**

§ 371 (c)(1),
(2) Date: **Jun. 1, 2023**

(87) PCT Pub. No.: **WO2022/116258**

PCT Pub. Date: **Jun. 9, 2022**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 7/00 (2006.01)
H01Q 21/28 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 7/005** (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 7/005; H01Q 21/28
See application file for complete search history.

(56) **References Cited**

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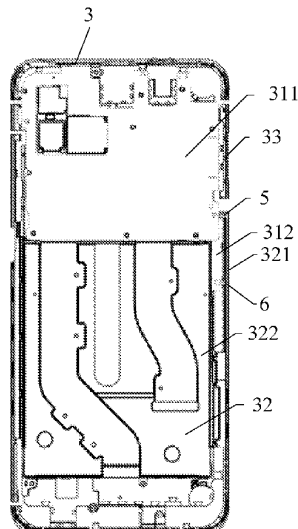
Primary Examiner — Graham P Smith

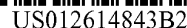
(74) *Attorney, Agent, or Firm* — PV IP PC; Wei Te Chung

(57) **ABSTRACT**

An antenna structure includes a middle frame body. The middle frame body includes a main board and an embedded metal, the embedded metal includes a metal body part and a metal extension part, the metal main body part and the metal extension part are an integral structure, the main board includes a first main board and a second main board, the first main board is electrically connected to the metal extension part, the first main board is configured to introduce a radio frequency signal into the metal extension part, the second main board is electrically connected to the metal extension part, and the second main board is configured to ground the metal extension part.

19 Claims, 7 Drawing Sheets





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(45) **Date of Patent:** Apr. 28, 2026

(58) **Field of Classification Search**

CPC H01Q 1/526; H01Q 1/2283; H01Q 1/48;
H01Q 1/22; H01Q 1/521; H01Q 21/0075;
H01Q 21/065; H01Q 25/001; H01Q 1/36;
H01Q 1/38; H01Q 21/00

See application file for complete search history.

(56) **References Cited**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 59 days.

(21) Appl. No.: 18/935,663

(Continued)

(22) Filed: **Nov. 4, 2024**

FOREIGN PATENT DOCUMENTS

(65) **Prior Publication Data**

CN	112186359	1/2021
CN	117650369	3/2024

US 2025/0192428 A1 Jun. 12, 2025

Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Bamidele A Immanuel

(74) *Attorney, Agent, or Firm* — JCIPRNET

Related U.S. Application Data

(60) Provisional application No. 63/606,806, filed on Dec. 6, 2023.

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

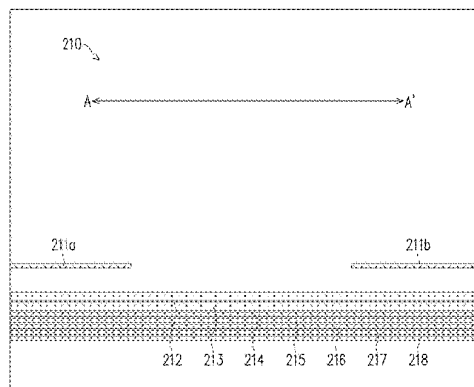
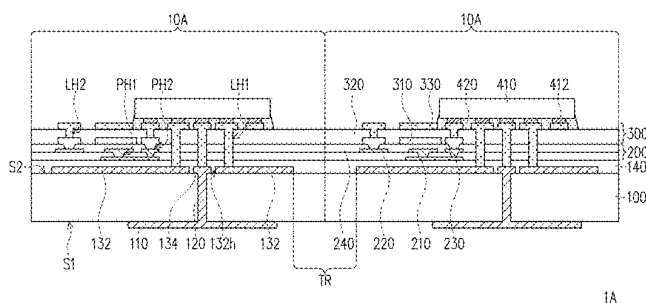
Jul. 19, 2024 (TW) 113127157

(51) **Int. Cl.**
H01Q 1/36 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 1/52 (2006.01)

(52) **U.S. Cl.**
CPC *H01Q 1/526* (2013.01); *H01Q 1/2283*
(2013.01); *H01Q 1/48* (2013.01)

An antenna device includes a transparent substrate and a plurality of antenna units arranged on the transparent substrate. Each antenna unit includes an antenna electrode, a ground electrode, a thin-film circuit structure, a redistribution structure and a chip. The redistribution structure includes a digital signal pad, an analog signal pad, a radio frequency (RF) signal pad, and an antenna signal pad. The chip is bonded to the digital signal pad, the analog signal pad, the RF signal pad, and the antenna signal pad. The digital signal pad and the analog signal pad are disposed in a first bonding area. The RF signal pad and the antenna signal pad are disposed in a second bonding area.

11 Claims, 15 Drawing Sheets





US012614847B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 12,614,847 B2**
(45) **Date of Patent:** **Apr. 28, 2026**

(54) **ANTENNA STRUCTURE AND MOBILE DEVICE**

(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)

(72) Inventors: **Yueh-Chan Lee**, Hsinchu (TW);
Cheng-Da Yang, Hsinchu (TW)

(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 36 days.

(21) Appl. No.: **18/827,619**

(22) Filed: **Sep. 6, 2024**

(65) **Prior Publication Data**

US 2025/0112364 A1 Apr. 3, 2025

(30) **Foreign Application Priority Data**

Sep. 28, 2023 (TW) 112137389

(51) **Int. Cl.**
H01Q 5/314 (2015.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/20 (2015.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 5/314** (2015.01); **H01Q 1/2266** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/20** (2015.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2266; H01Q 1/2291; H01Q 1/241–243; H01Q 1/38; H01Q 1/48; H01Q 9/04; H01Q 9/42; H01Q 5/378–392

See application file for complete search history.

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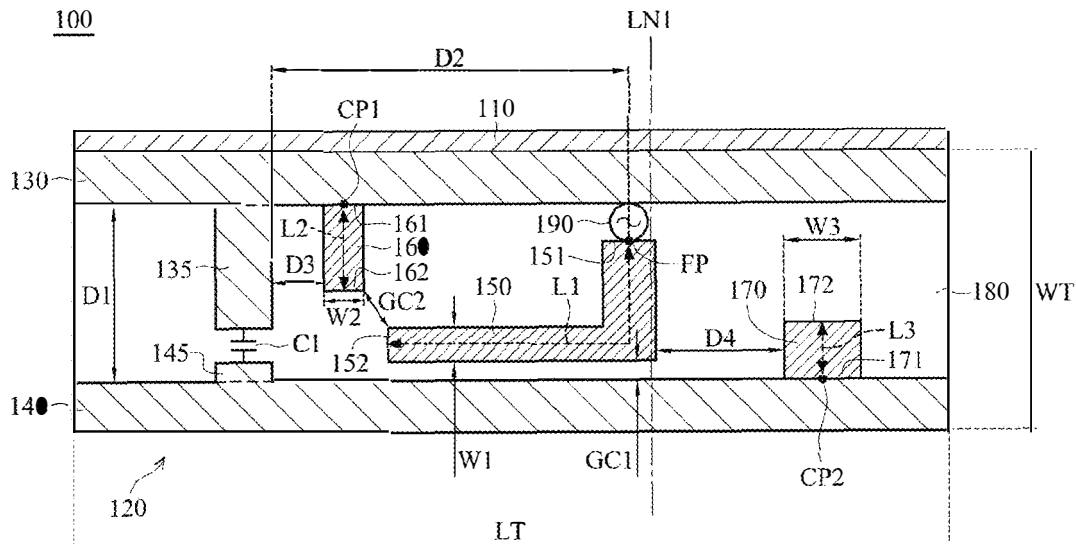
Primary Examiner — Hasan Islam

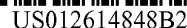
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a ground element, a metal cavity, a first radiation element, a second radiation element, a third radiation element, and a capacitive element. The metal cavity includes a first edge segment and a second edge segment which are opposite to each other. The first edge segment is coupled to the ground element. The first radiation element has a feeding point. The first radiation element is adjacent to the second edge segment. The second radiation element is coupled to the first edge segment. The second radiation element is adjacent to the first radiation element. The third radiation element is coupled to the second edge segment. The capacitive element is coupled between the first edge segment and the second edge segment. The first radiation element, the second radiation element, and the third radiation element are disposed between the first edge segment and the second edge segment.

20 Claims, 7 Drawing Sheets





(10) **Patent No.:** US 12,614,848 B2
(45) **Date of Patent:** Apr. 28, 2026

(56) **References Cited**

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Primary Examiner — Dimary S Lopez Cruz
Assistant Examiner — Anna N Hamadyk
(74) Attorney, Agent, or Firm — Myers Bigel, P.A.

(57) **ABSTRACT**

The present disclosure relates to a radiating element, which includes: a dipole arm configured to emit first electromagnetic radiation within a pre-determined first operating frequency band; and a parasitic radiator, configured such that a first induced current induced on the parasitic radiator within a second operating frequency band at least partially cancels a second induced current induced on the dipole arm within the second operating frequency band. In addition, the present disclosure relates to a base station antenna, including: a first radiating element array, configured to emit first electromagnetic radiation within a pre-determined first operating frequency band, and at least a part of first radiating elements in the first radiating element array is constructed as radiating elements according to the present disclosure; a second radiating element array, configured to emit second electromagnetic radiation within a pre-determined second operating frequency band.

17 Claims, 7 Drawing Sheets

Diagram illustrating a cross-shaped structure. The central square is labeled 20. The four arms extending from the center are labeled 23. The arms are connected to a central square by dashed lines, with arrows indicating a clockwise flow. The arms are labeled 30. The central square is labeled 40.



US012614849B2

(12) **United States Patent**
Ye et al.

(10) **Patent No.:** **US 12,614,849 B2**
(45) **Date of Patent:** **Apr. 28, 2026**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(72) Inventors: **Mao Ye**, Xi'an (CN); **Hanyang Wang**, Reading (GB); **Meng Hou**, Shanghai (CN); **Liang Xue**, Shanghai (CN); **Kun Li**, Xi'an (CN)

(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 32 days.

(21) Appl. No.: **18/722,437**

(22) PCT Filed: **Dec. 21, 2022**

(86) PCT No.: **PCT/CN2022/140767**

§ 371 (c)(1),

(2) Date: **Jun. 20, 2024**

(87) PCT Pub. No.: **WO2023/116780**

PCT Pub. Date: **Jun. 29, 2023**

(65) **Prior Publication Data**

US 2025/0062533 A1 Feb. 20, 2025

(30) **Foreign Application Priority Data**

Dec. 23, 2021 (CN) 202111586570.X

(51) **Int. Cl.**
H01Q 5/50 (2015.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 5/50** (2015.01); **H01Q 1/243** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/10** (2015.01); **H03H 7/38** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/50; H01Q 1/243; H01Q 1/48;
H01Q 5/10; H01Q 5/25; H01Q 9/0407;
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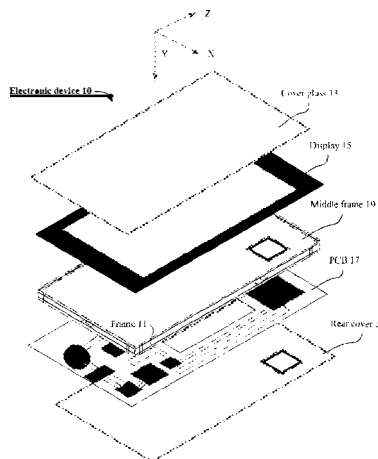
Primary Examiner — Seung H Lee

(74) *Attorney, Agent, or Firm* — WOMBLE BOND
DICKINSON (US) LLP

(57) **ABSTRACT**

An electronic device includes a radiator, a feed point, and a ground point. The plurality of radiators include a first radiator, a second radiator, and a third radiator. A first end of the first radiator and a first end of the second radiator are opposite to each other, and form a first gap. A second end of the first radiator and a first end of the third radiator are opposite to each other, and form a second gap. The feed point and the ground point are disposed on the first radiator. The ground point is disposed in a central region of the plurality of radiators or the first radiator, and the feed point is disposed between the central region and the first end of the first radiator. Gaps are formed between a plurality of radiators, so that a broadband antenna can be implemented.

17 Claims, 16 Drawing Sheets





US012614850B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 12,614,850 B2**
(45) **Date of Patent:** **Apr. 28, 2026**

(54) **SEMICONDUCTOR PACKAGE INCLUDING ANTENNA AND METHOD OF MANUFACTURING THE SEMICONDUCTOR PACKAGE**

(71) Applicant: **NEPES CO., LTD.**, Eumseong-gun (KR)

(72) Inventors: **Jung Won Lee**, Eumseong-gun (KR); **Ju Eok Park**, Eumseong-gun (KR); **In Soo Kang**, Eumseong-gun (KR)

(73) Assignee: **NEPES CO., LTD.**, Eumseong-gun (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 559 days.

(21) Appl. No.: **18/145,047**

(22) Filed: **Dec. 22, 2022**

(65) **Prior Publication Data**

US 2023/0216201 A1 Jul. 6, 2023

(30) **Foreign Application Priority Data**

Jan. 4, 2022 (KR) 10-2022-0001033
Sep. 29, 2022 (KR) 10-2022-0124651

(51) **Int. Cl.**
H01L 23/48 (2006.01)
H01L 21/48 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01L 21/4857** (2013.01); **H01L 21/563** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . H01Q 9/0407; H01L 21/4857; H01L 21/563;
H01L 23/3128; H01L 23/49811; H01L 23/49822; H01L 24/16

See application file for complete search history.

(56) **References Cited**

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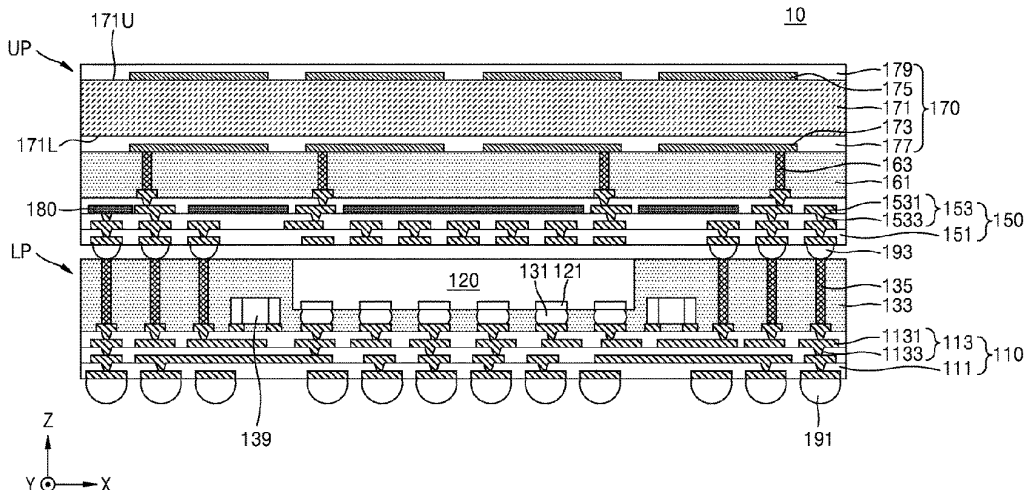
Primary Examiner — Nicholas J Tobergte

(74) *Attorney, Agent, or Firm* — Harvest IP LAW LLP

(57) **ABSTRACT**

A semiconductor package includes: a lower package; and an upper package stacked on the lower package, wherein the lower package includes: a first redistribution structure; a semiconductor chip mounted on the first redistribution structure; a first molding layer surrounding the semiconductor chip on the first redistribution structure; and first vertical connection conductors disposed on the first redistribution structure and vertically passing through the first molding layer, wherein the upper package includes: a second molding layer disposed on the lower package; second vertical connection conductors vertically passing through the second molding layer and electrically connected to the first vertical connection conductors; and an antenna structure disposed on the second molding layer.

19 Claims, 33 Drawing Sheets





US012614852B2

(12) **United States Patent**
Yue et al.

(10) **Patent No.:** **US 12,614,852 B2**
(45) **Date of Patent:** **Apr. 28, 2026**

(54) **COMMUNICATION TERMINAL WITH
INTERWOVEN AND FREE-STANDING
ANTENNA RADIATORS**

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(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Taiwei Yue**, Union City, CA (US);
Matthew N Ettus, Monte Sereno, CA
(US); **Jeffrey K Tu**, Mountain View,
CA (US); **Kyle J Cormany**,
Atascadero, CA (US)

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(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 196 days.

Primary Examiner — Hai V Tran

(21) Appl. No.: **18/525,476**

(74) Attorney, Agent, or Firm — Treyz Law Group, P.C.;
Michael H. Lyons

(22) Filed: **Nov. 30, 2023**

(65) **Prior Publication Data**

US 2025/0183540 A1 Jun. 5, 2025

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

A communication terminal may include interwoven high and low band phased array antennas that form signal beams in respective bands. The high band antenna may have center-grounded folded patch radiators. The low band antenna may have folded patch radiators that each surrounds a different respective center-grounded folded patch radiator of the high band antenna. The low and high band antennas may be mounted to ground traces on an antenna board. The antenna board may be mounted to a feeding board. Beamforming circuitry for the low and high band antennas may be disposed on the feeding board. The patch radiators of the low and high band antennas may be formed from free-standing folded sheet metal. The folded sheet metal may be mounted to the antenna board by conductive standoffs. The conductive standoffs may be used to feed the antenna radiators and/or to short the antenna radiators to the ground trace.

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/24**
(2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 1/24; H01Q 1/48;
H01Q 1/50
See application file for complete search history.

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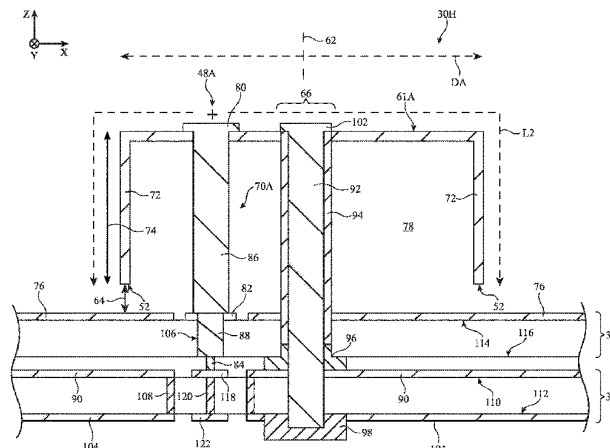
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20 Claims, 9 Drawing Sheets





US012614857B2

(12) **United States Patent**
Jargalsaikhan et al.

(10) **Patent No.:** **US 12,614,857 B2**
(45) **Date of Patent:** **Apr. 28, 2026**

(54) **MULTIBAND BASE STATION ANTENNA
HAVING IMPROVED BEAMWIDTH**

(71) Applicant: **ACE TECHNOLOGIES
CORPORATION**, Incheon (KR)
(72) Inventors: **Nyambayar Jargalsaikhan**, Incheon
(KR); **Ho-Yong Kim**, Incheon (KR);
Jeong Geun Park, Daejeon (KR); **Eun
Suk Yang**, Incheon (KR)

(73) Assignee: **ACE TECHNOLOGIES
CORPORATION**, Incheon (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 167 days.

(21) Appl. No.: **18/748,729**

(22) Filed: **Jun. 20, 2024**

(65) **Prior Publication Data**
US 2024/0339761 A1 Oct. 10, 2024

Related U.S. Application Data
(63) Continuation of application No.
PCT/KR2022/095147, filed on Oct. 19, 2022.

(30) **Foreign Application Priority Data**
Dec. 23, 2021 (KR) 10-2021-0185743

(51) **Int. Cl.**
H01Q 21/26 (2006.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 15/14** (2013.01); **H01Q 1/246**
(2013.01); **H01Q 1/523** (2013.01); **H01Q 5/42**
(2015.01); **H01Q 21/26** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/246; H01Q 1/523; H01Q 5/42;
H01Q 21/26
See application file for complete search history.

(56) **References Cited**

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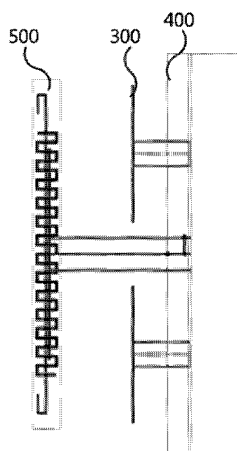
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PCT/KR2022/095147 issued on Feb. 20, 2023.
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Primary Examiner — Daniel Munoz

(57) **ABSTRACT**

A multiband base station antenna having improved beamwidth is disclosed. The disclosed antenna comprises: a reflective plate; a plurality of first low-band radiators arranged on the reflective plate along a first column; a plurality of second low-band radiators arranged on the reflective plate along a second column, which is parallel to the first column and is spaced from the first column; a plurality of high-band radiators arranged on the reflective plate; and a plurality of vertical choke members arranged, between the first column and the second column, in the direction parallel to that of the first column and the second column, wherein the vertical choke members comprise a first substrate, a meander line is formed on the first substrate, and a metal line is formed under the first substrate. According to the disclosed antenna, beamwidth distortion of each radiator, caused by interference between the radiators, can be prevented, and proper isolation characteristics between the radiators can be ensured.

13 Claims, 12 Drawing Sheets





US012620712B2

(12) **United States Patent**
Kawabe

(10) **Patent No.:** **US 12,620,712 B2**
(45) **Date of Patent:** **May 5, 2026**

(54) **MULTILAYER BOARD AND ANTENNA
MODULE**

(56) **References Cited**

U.S. PATENT DOCUMENTS

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
Nagaokakyo (JP)

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(72) Inventor: **Kentarou Kawabe**, Nagaokakyo (JP)

FOREIGN PATENT DOCUMENTS

(73) Assignee: **MURATA MANUFACTURING CO.,
LTD.**, Nagaokakyo (JP)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 157 days.

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(21) Appl. No.: **18/463,302**

Office Action issued on Sep. 16, 2025, in corresponding Japanese
patent Application No. 2023-097403, 3 pages.

(22) Filed: **Sep. 8, 2023**

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(65) **Prior Publication Data**

US 2024/0088565 A1 Mar. 14, 2024

Primary Examiner — Henry Luong

(74) Attorney, Agent, or Firm — XSENSUS LLP

(30) **Foreign Application Priority Data**

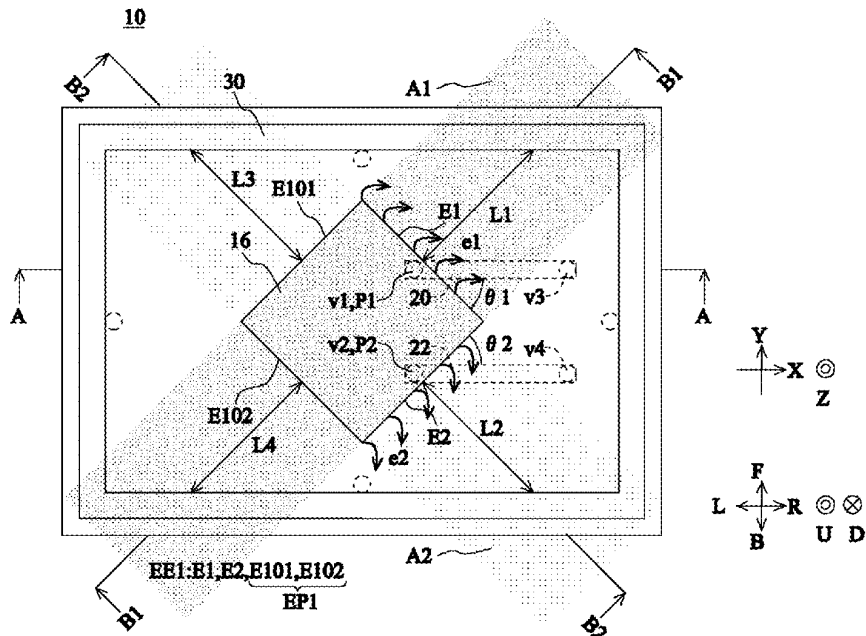
Sep. 13, 2022 (JP) 2022-145551
Jun. 14, 2023 (JP) 2023-097403

(57) **ABSTRACT**

A multilayer board includes a multilayer body including a
first radiation conductor layer, a ground conductor layer, a
first wiring layer, and a second wiring layer. The first wiring
layer is electrically connected to a first radiation conductor
layer at a first power supply point positioned closest to a first
straight line in a first outer edge and intersects but is not
orthogonal to the first straight line in a view along a Z-axis
direction. The second wiring layer is electrically connected
to the first radiation conductor layer at a second power
supply point positioned closest to a second straight line in
the first outer edge and intersects but is not orthogonal to the
second straight line in a view along the Z-axis direction.

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/38**
(2013.01)
(58) **Field of Classification Search**
CPC H01Q 9/0407; H01Q 1/38
See application file for complete search history.

18 Claims, 23 Drawing Sheets





US012620713B2

(12) **United States Patent**
Takayama et al.

(10) **Patent No.:** **US 12,620,713 B2**
(45) **Date of Patent:** **May 5, 2026**

(54) **PATCH ANTENNA AND ANTENNA DEVICE**

(56) **References Cited**

(71) Applicant: **YOKOWO CO., LTD.**, Tokyo (JP)

U.S. PATENT DOCUMENTS

(72) Inventors: **Yuki Takayama**, Tomioka (JP); **Bunpei Hara**, Tomioka (JP)

5,767,810 A 6/1998 Hagiwara et al.

(73) Assignee: **YOKOWO CO., LTD.**, Tokyo (JP)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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WO	96/34426	A1	10/1996	

(21) Appl. No.: **18/689,503**

(22) PCT Filed: **Sep. 7, 2022**

(86) PCT No.: **PCT/JP2022/033526**

§ 371 (c)(1),

(2) Date: **Mar. 6, 2024**

(87) PCT Pub. No.: **WO2023/047954**

PCT Pub. Date: **Mar. 30, 2023**

(65) **Prior Publication Data**

US 2025/0141109 A1 May 1, 2025

(30) **Foreign Application Priority Data**

Sep. 22, 2021 (JP) 2021-153829

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 21/06 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 21/065** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/32; H01Q 1/34; H01Q 1/36; H01Q 1/38; H01Q 1/48; H01Q 1/50; H01Q 9/0407; H01Q 9/0414; H01Q 13/08; H01Q 21/065

See application file for complete search history.

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Office Action issued Dec. 9, 2025 in counterpart Japanese patent application No. JP2023-549462 (11 pages; with English machine translation).

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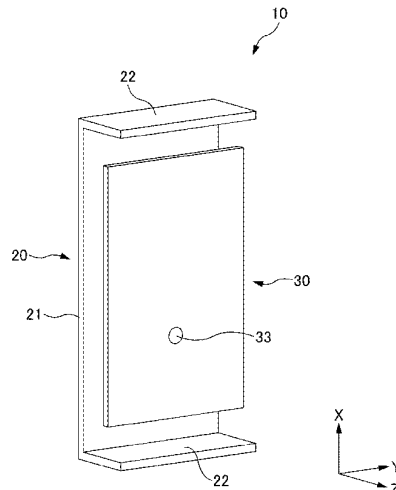
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — XSENSUS LLP

(57) **ABSTRACT**

A patch antenna includes: a first element; and a second element located so as to face the first element, wherein the first element includes a first main body portion facing the second element, and at least one first bent portion extending from the first main body portion toward the second element, and a wave source is generated between the second element and the first bent portion.

20 Claims, 20 Drawing Sheets





(10) **Patent No.:** US 12,620,718 B2
(45) **Date of Patent:** May 5, 2026

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- * cited by examiner

- Primary Examiner — Daniel Munoz
(74) Attorney, Agent, or Firm — Spencer Fane, LLP

- (57) **ABSTRACT**

- PCT Pub. Date:
- Oct. 5, 2023**

- A MIMO antenna device includes a front-side dipole antenna and a back-side dipole antenna. Long-side feed parts for hot element are connected respectively to feed points at their long sides. Long-side feed parts for ground element are connected respectively to the feed points at their long sides, and the long sides thereof face the long sides of the long-side feed parts for hot element in parallel with a predetermined interval. Ground elements are respectively arranged point-symmetric to hot elements with respect to the feed points in an offset manner. The front-side dipole antenna and the back-side dipole antenna are arranged such that the front-side feed point and the back-side feed point substantially overlap each other in a top view and that the long-side feed part for front-side is arranged perpendicular to the long-side feed part for back-side.

- US 2025/0219294 A1 Jul. 3, 2025

- (30) **Foreign Application Priority Data**

- Mar. 28, 2022 (JP) 2022-052402

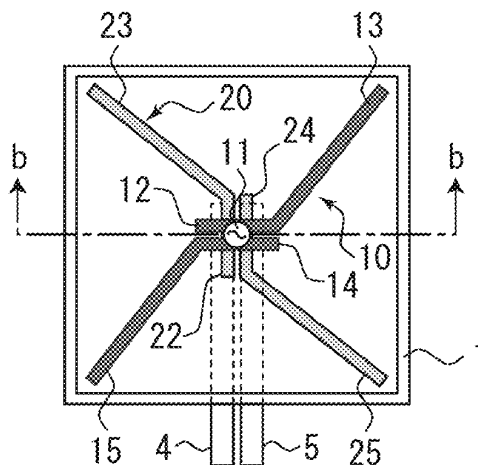
- (51) **Int. Cl.**
H01Q 9/28 (2006.01)
H01Q 1/52 (2006.01)
H01Q 9/26 (2006.01)

- (52) **U.S. Cl.**
CPC *H01Q 9/28* (2013.01); *H01Q 1/521*
(2013.01); *H01Q 9/26* (2013.01)

- (58) **Field of Classification Search**
CPC H01Q 1/521; H01Q 9/26; H01Q 9/28;
H01Q 21/28

- See application file for complete search history.

- 10 Claims, 3 Drawing Sheets**





US012620719B2

(12) **United States Patent**
Li et al.

(10) **Patent No.:** **US 12,620,719 B2**
(45) **Date of Patent:** **May 5, 2026**

(54) **PLANAR TRANSPARENT ANTENNA
STRUCTURE**

(71) Applicant: **INDUSTRIAL TECHNOLOGY
RESEARCH INSTITUTE**, Hsinchu
(TW)

(72) Inventors: **Bing-Syun Li**, Hsinchu City (TW);
Li-Yang Tsai, Luodong Township
(TW); **Kuang-Hui Shih**, Tainan City
(TW); **Ruo-Lan Chang**, New Taipei
City (TW); **Kung-Ching Chu**, Taipei
City (TW); **Wei-Chung Chen**, Zhunan
Township (TW)

(73) Assignee: **INDUSTRIAL TECHNOLOGY
RESEARCH INSTITUTE**, Hsinchu
(TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 83 days.

(21) Appl. No.: **18/625,964**

(22) Filed: **Apr. 3, 2024**

(65) **Prior Publication Data**
US 2024/0339758 A1 Oct. 10, 2024

Related U.S. Application Data
(60) Provisional application No. 63/457,428, filed on Apr.
6, 2023.

(30) **Foreign Application Priority Data**
Jan. 24, 2024 (TW) 113102792

(51) **Int. Cl.**
H01Q 9/28 (2006.01)
H01Q 1/38 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/285** (2013.01); **H01Q 1/38**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/285; H01Q 1/38
See application file for complete search history.

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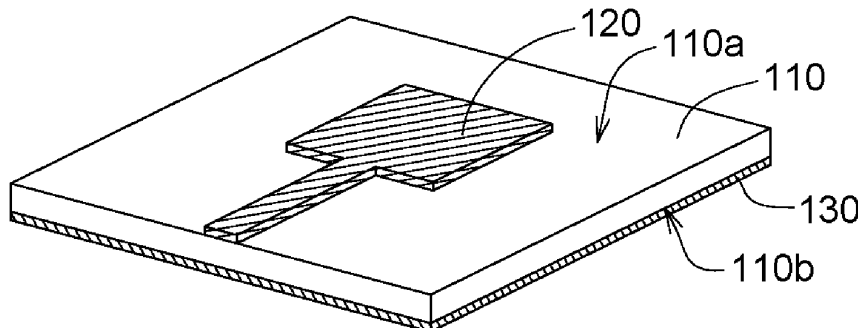
Primary Examiner — Seung H Lee
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch
& Birch, LLP

(57) **ABSTRACT**

A planar transparent antenna structure is provided. The
planar transparent antenna structure includes a dielectric
substrate, a radiation conductive layer and a ground con-
ductive layer. The dielectric substrate has a first surface and
a second surface. The radiation conductive layer is disposed
on the first surface of the dielectric substrate. The ground
conductive layer is disposed on the second surface of the
dielectric substrate. The radiation conductive layer and the
ground conductive layer are composed of a plurality of wires
connected in a mesh manner. Each of the wires is composed
of a plurality of grid lines connected in a mesh manner.

20 Claims, 11 Drawing Sheets

100





US012620723B2

(12) **United States Patent**
Zhang et al.

(10) **Patent No.:** **US 12,620,723 B2**
(45) **Date of Patent:** **May 5, 2026**

(54) **DUAL-POLARIZED MAGNETOELECTRIC
DIPOLE ANTENNA AND ELECTRONIC
DEVICE**

(71) Applicants: **Beijing BOE Technology Development
Co., Ltd.**, Beijing (CN); **BOE
Technology Group Co., Ltd.**, Beijing
(CN)

(72) Inventors: **Dongdong Zhang**, Beijing (CN);
Shihua Wang, Beijing (CN); **Youjian
Hu**, Beijing (CN); **Yali Wang**, Beijing
(CN); **Feng Qu**, Beijing (CN); **Biqi Li**,
Beijing (CN)

(73) Assignees: **Beijing BOE Technology Development
Co., Ltd.**, Beijing (CN); **BOE
Technology Group Co., Ltd.**, Beijing
(CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 202 days.

(21) Appl. No.: **18/579,334**

(22) PCT Filed: **Dec. 26, 2022**

(86) PCT No.: **PCT/CN2022/141915**

§ 371 (c)(1),

(2) Date: **Jan. 13, 2024**

(87) PCT Pub. No.: **WO2024/138312**

PCT Pub. Date: **Jul. 4, 2024**

(65) **Prior Publication Data**

US 2025/0087896 A1 Mar. 13, 2025

(51) **Int. Cl.**
H01Q 19/10 (2006.01)
H01Q 21/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 19/108** (2013.01); **H01Q 21/24**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 19/108; H01Q 21/24
See application file for complete search history.

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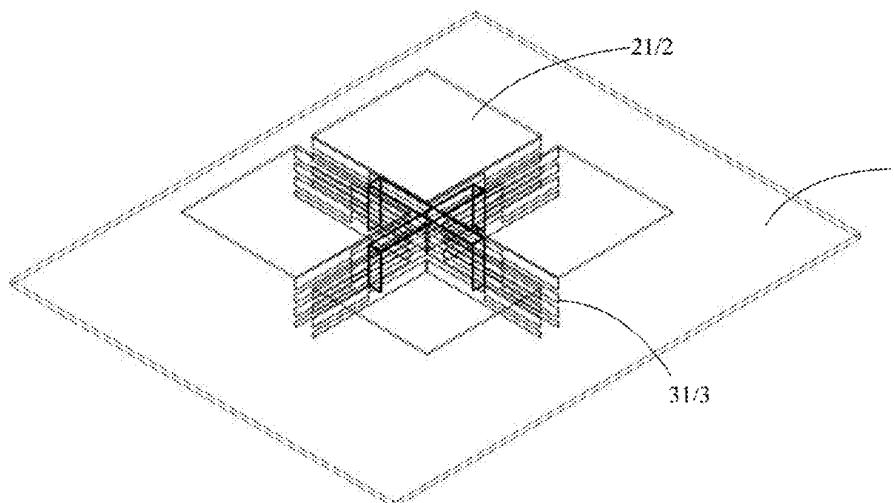
Primary Examiner — David E Lotter

(74) *Attorney, Agent, or Firm* — HOUTTEMAN LAW
LLC

(57) **ABSTRACT**

A dual-polarized magnetoelectric dipole antenna, including a reflection plate, electric and magnetic dipoles, where the electric dipole includes four first electrodes; the magnetic dipole includes four second electrodes; the second electrodes are in one-to-one correspondence with the first electrodes, and each second electrode is connected between a corresponding first electrode and the reflection plate; each first electrode includes first and second sides connected to each other; the first side of the first electrode is adjacent to the first side of one adjacent first electrode, and the second side of the first electrode is adjacent to the second side of other one adjacent first electrode; each second electrode includes two sub-electrodes connected to the first and second sides of a corresponding first electrode, respectively; the sub-electrode has a slit opening therein, and an extending direction of the slit opening is parallel to a plane where the reflection plate is located.

19 Claims, 24 Drawing Sheets





US012621379B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 12,621,379 B2**
(45) **Date of Patent:** **May 5, 2026**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(72) Inventors: **Hanyang Wang**, Reading (GB); **Kexin Liu**, Shanghai (CN); **Dong Yu**, Shanghai (CN)

(73) Assignee: **Huawei Technologies Co., Ltd.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 596 days.

(21) Appl. No.: **18/008,385**

(22) PCT Filed: **May 19, 2021**

(86) PCT No.: **PCT/CN2021/094633**

§ 371 (c)(1),

(2) Date: **Dec. 5, 2022**

(87) PCT Pub. No.: **WO2021/244293**

PCT Pub. Date: **Dec. 9, 2021**

(65) **Prior Publication Data**

US 2023/0283698 A1 Sep. 7, 2023

(30) **Foreign Application Priority Data**

Jun. 5, 2020 (CN) 202010504820.X

(51) **Int. Cl.**
H04M 1/02 (2006.01)
H01Q 1/22 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H04M 1/026** (2013.01); **H01Q 1/22** (2013.01); **H01Q 13/10** (2013.01); **H01Q 19/17** (2013.01)

(58) **Field of Classification Search**

CPC H04M 1/026; H01Q 1/22; H01Q 13/10; H01Q 19/17

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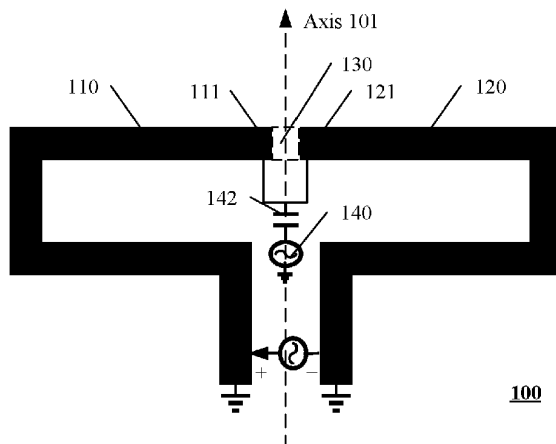
Primary Examiner — Michael R Neff

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

Electronic devices and antenna structures are described. An example electronic device includes an antenna structure, wherein the antenna structure includes: a first radiator and a second radiator, wherein the first radiator includes a first end and a second end, and the second radiator includes a first end and a second end. The first end of the first radiator and the first end of the second radiator face each other and are not in contact with each other, and a slot is formed between the first end of the first radiator and the first end of the second radiator. The first radiator and the second radiator are disposed in a bent manner, and a spatial region formed between the first radiator, the second radiator, and the slot is T-shaped; and the second end of the first radiator is grounded, and the second end of the second radiator is grounded.

20 Claims, 24 Drawing Sheets





US012627024B2

(12) **United States Patent**
Cogoni

(10) **Patent No.:** **US 12,627,024 B2**
(45) **Date of Patent:** **May 12, 2026**

(54) **ANTENNA PACKAGE**

(56)

References Cited

(71) Applicant: **STMicroelectronics (Alps) SAS**,
Grenoble (FR)

U.S. PATENT DOCUMENTS

(72) Inventor: **Deborah Cogoni**, Notre Dame de
l'Osier (FR)

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(73) Assignee: **STMicroelectronics (Alps) SAS**,
Grenoble (FR)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 189 days.

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(21) Appl. No.: **18/545,106**

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(22) Filed: **Dec. 19, 2023**

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dated May 6, 2021 (11 pages).

(65) **Prior Publication Data**

US 2024/0120638 A1 Apr. 11, 2024

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Related U.S. Application Data

Primary Examiner — David E Lotter

(63) Continuation of application No. 17/408,982, filed on
Aug. 23, 2021, now Pat. No. 11,888,208.

(74) *Attorney, Agent, or Firm* — Crowe & Dunlevy LLC

(30) **Foreign Application Priority Data**

Aug. 25, 2020 (FR) 2008676

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/12 (2006.01)
H01Q 1/38 (2006.01)

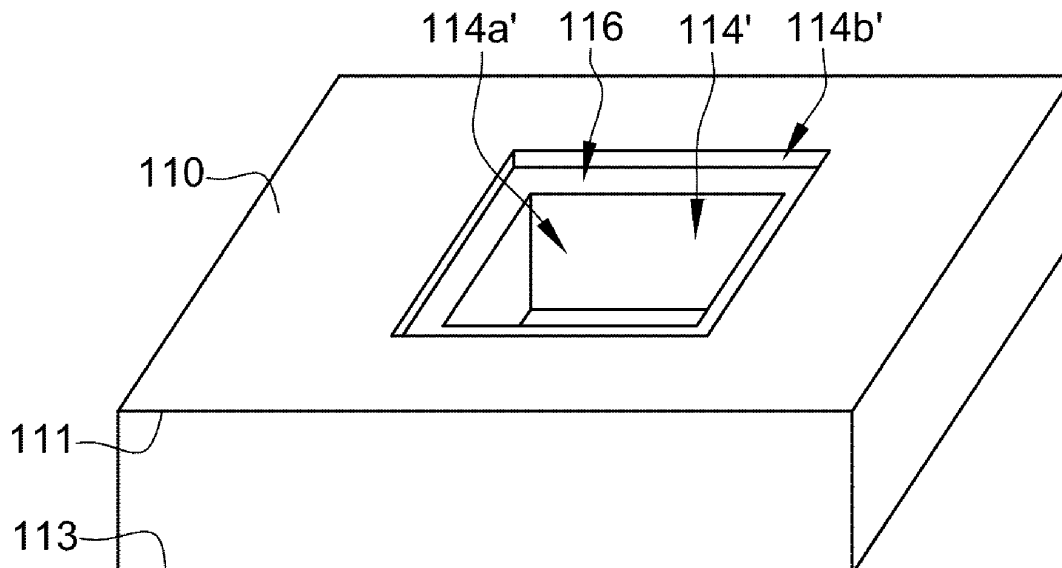
An electronic device includes a first layer with an antenna and a second metal layer that extends over the entire first layer. The second metal layer includes at least one laterally-closed cavity that is located vertically above the antenna. The cavity is filled, at least in part, by a resin material. A first plate supporting a second metal plate extends over the cavity with the second metal plate positioned vertically above the antenna. The first metal plate may be supported by a ledge within the cavity. Alternatively, the second metal plate is embedded in the resin filling the cavity, with the second metal plate positioned vertically above the antenna.

(52) **U.S. Cl.**
CPC **H01Q 1/12** (2013.01); **H01Q 1/38**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/12; H01Q 1/38; H01Q 1/2283;
H01Q 9/0414

See application file for complete search history.

18 Claims, 9 Drawing Sheets





US012627040B2

(12) **United States Patent**
Wu et al.

(10) **Patent No.:** **US 12,627,040 B2**
(45) **Date of Patent:** **May 12, 2026**

(54) **ANTENNA MODULE**

(56)

References Cited

(71) Applicant: **ACCTON TECHNOLOGY CORPORATION**, Hsinchu (TW)

(72) Inventors: **Chien-Hua Wu**, Miaoli County (TW);
Chun-Yi Kuo, Hsinchu (TW)

(73) Assignee: **ACCTON TECHNOLOGY CORPORATION**, Hsinchu (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 180 days.

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Primary Examiner — Ab Salam Alkassim, Jr.
(74) *Attorney, Agent, or Firm* — Apex Juris, pllc; Hilde M. L. Coeckx

(57)

ABSTRACT

An antenna module includes two antennas, a reflecting board, and a plurality of extending plates. The extending plate has a first surface and a second surface. The first surface extends along a first axis and a second axis perpendicular to the first axis. The two antennas are disposed on the first surface and spaced along the first axis. A spacing zone is defined in the reflecting board and located between the two antennas along the first axis. The spacing zone has a shielding portion. A periphery of the shielding portion has a plurality of open grooves. Each open groove penetrates through the first surface and the second surface. The shielding portion has a plurality of side edges, wherein each side edge is adjacent to each open groove. Each extending plate extends towards the second surface. The shielding portion and the extending plates jointly form a shielding cover.

18 Claims, 27 Drawing Sheets

(65) **Prior Publication Data**

US 2025/0105501 A1 Mar. 27, 2025

(30) **Foreign Application Priority Data**

Sep. 21, 2023 (CN) 202322570302.X

(51) **Int. Cl.**

H01Q 1/52 (2006.01)

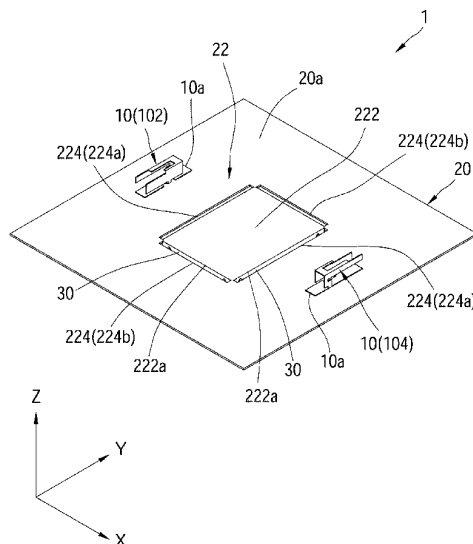
H01Q 19/10 (2006.01)

(52) **U.S. Cl.**

CPC **H01Q 1/521** (2013.01); **H01Q 1/526**
(2013.01); **H01Q 19/104** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/52–525; H01Q 19/104
See application file for complete search history.





US012627053B1

(12) **United States Patent**
Paschen et al.

(10) **Patent No.:** **US 12,627,053 B1**
(45) **Date of Patent:** **May 12, 2026**

(54) **PATCH ANTENNA ELEMENT WITH
REACTIVE AREAL LOADING**

(71) Applicant: **FIRST RF Corporation**, Boulder, CO
(US)

(72) Inventors: **Dean Paschen**, Superior, CO (US);
Lars Grimsrud, Broomfield, CO (US)

(73) Assignee: **FIRST RF Corporation**, Boulder, CO
(US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 552 days.

(21) Appl. No.: **17/723,946**

(22) Filed: **Apr. 19, 2022**

Related U.S. Application Data

(60) Provisional application No. 63/176,802, filed on Apr.
19, 2021.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)
H01Q 25/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 25/001** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38–48; H01Q 9/0407; H01Q
21/065; H01Q 15/008
See application file for complete search history.

(56) **References Cited**

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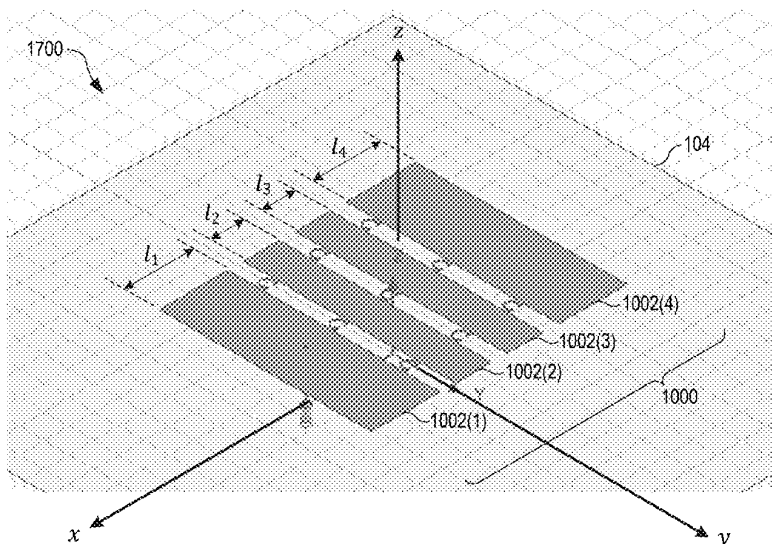
Primary Examiner — Hasan Islam

(74) *Attorney, Agent, or Firm* — Cozen O'Connor

(57) ABSTRACT

A patch antenna element has a plurality of patches that are coplanar, each having a length along a resonant dimension that is no greater than one-quarter of a wavelength of a maximum operating frequency of the patch antenna element. The antenna element also includes one or more discrete reactive elements. For each pair of neighboring patches of the plurality of patches, the pair forms an electrically insulating space therebetween. At least one discrete reactive element lies within the electrically insulating space and is electrically connected to both of the neighboring patches of the pair. A patch antenna combines the patch antenna element with a counterpoise that is parallel to, and displaced from, the patch antenna element. Each discrete reactive element may be an inductor or capacitor, either planar or non-planar. The patch antenna may be configured as a dual-polarization patch antenna or quarter-wave patch antenna.

17 Claims, 19 Drawing Sheets





US012627054B2

(12) **United States Patent**
Jhang et al.

(10) **Patent No.:** **US 12,627,054 B2**
(45) **Date of Patent:** **May 12, 2026**

(54) **ANTENNA DEVICE**

(71) Applicant: **AUO Corporation**, Hsinchu City (TW)

(72) Inventors: **Zong-Long Jhang**, Hsinchu City (TW);
Hsiu-Yin Cheng, Hsinchu City (TW);
Yi-Hui Lin, Hsinchu City (TW)

(73) Assignee: **AUO Corporation**, Hsinchu City (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 71 days.

(21) Appl. No.: **18/931,011**

(22) Filed: **Oct. 29, 2024**

(65) **Prior Publication Data**

US 2025/0192435 A1 Jun. 12, 2025

Related U.S. Application Data

(60) Provisional application No. 63/606,806, filed on Dec. 6, 2023.

(30) **Foreign Application Priority Data**

Jun. 21, 2024 (TW) 113123075

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0407** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0407; H01Q 1/48; H01Q 1/364;
H01Q 1/40; H01Q 9/0457; H01Q 21/065;
H01Q 1/2283; H01Q 1/38; H01Q 1/12;
H01Q 1/50

See application file for complete search history.

(56) **References Cited**

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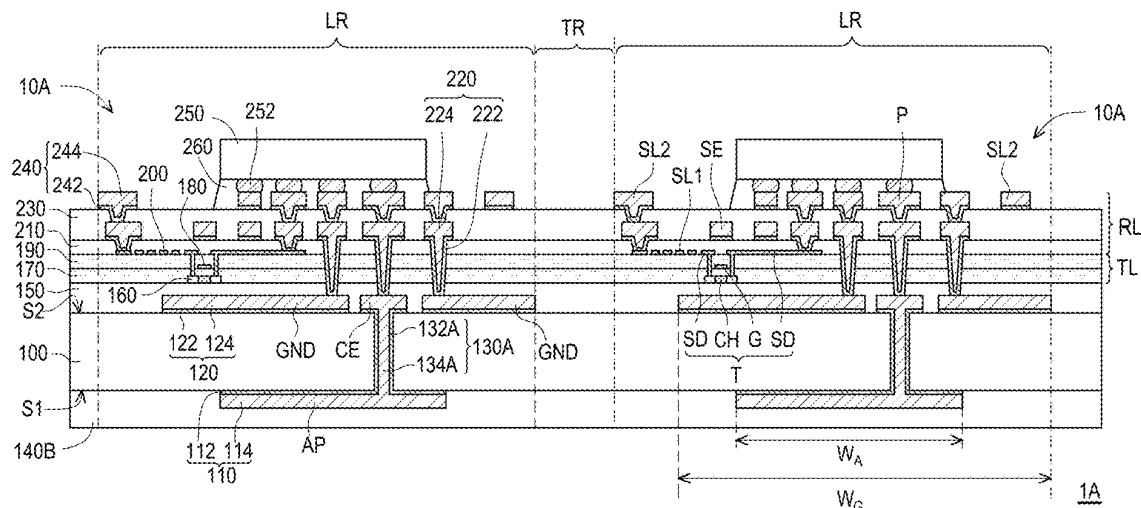
Primary Examiner — David E Lotter

(74) *Attorney, Agent, or Firm* — JCIPRNET

(57) **ABSTRACT**

A transparent antenna device includes a transparent substrate, an antenna electrode layer, an active device layer, a redistribution structure and a chip. The antenna electrode layer is located on the first surface of the transparent substrate and includes an antenna electrode located in a circuit layout region of the transparent antenna device. The active device layer is located above the second surface of the transparent substrate and includes an active device located in the circuit layout region. The redistribution structure is located on the active device layer and includes a signal line and a pad located in the circuit layout region. The chip is bonded to the pad of the redistribution structure and is located in the circuit layout region. The transparent antenna device has a light transmitting region located next to the circuit layout region.

10 Claims, 35 Drawing Sheets





US012627055B2

(12) **United States Patent**
Han et al.

(10) **Patent No.:** **US 12,627,055 B2**
(45) **Date of Patent:** **May 12, 2026**

(54) **ELECTRONIC DEVICE COMPRISING A PLURALITY OF ANTENNAS ARRANGED TO PREVENT RESTRICTION OF A RADIO FREQUENCY SIGNAL**

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 1/243; H01Q 3/34;
H01Q 9/0421; H01Q 21/205; H01Q 1/241;

(Continued)

(71) Applicant: **Samsung Electronics Co., Ltd.**,
Gyeonggi-do (KR)

(56) **References Cited**

(72) Inventors: **Junhee Han**, Gyeonggi-do (KR);
Pilwon Seo, Gyeonggi-do (KR);
Muyeol Lee, Gyeonggi-do (KR); **Inho Shin**, Gyeonggi-do (KR); **Jiwoo Lee**,
Gyeonggi-do (KR)

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(73) Assignee: **Samsung Electronics Co., Ltd** (KR)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 795 days.

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KR 10-2019-0095076 8/2019
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(21) Appl. No.: **17/861,832**

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(22) Filed: **Jul. 11, 2022**

PCT/ISA/210 Search Report issued on PCT/KR2021/012889, Jan. 3, 2022, pp. 6.

(65) **Prior Publication Data**

US 2022/0352637 A1 Nov. 3, 2022

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Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2021/012889, filed on Sep. 17, 2021.

Primary Examiner — Dameon E Levi
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(30) **Foreign Application Priority Data**

Sep. 22, 2020 (KR) 10-2020-0122411

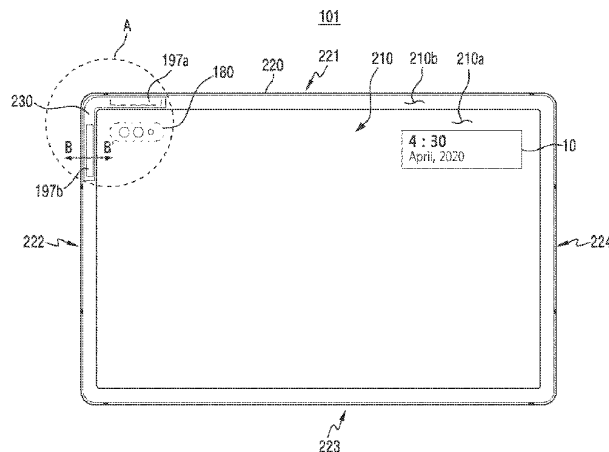
(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 3/34 (2006.01)
(Continued)

Disclosed is an electronic device including a window plate comprising a transparent region and an opaque region surrounding the transparent region, a display disposed below the transparent region of the window plate, a housing comprising a first face corresponding to a rear face of the display and a second face corresponding to a side face of the display, the housing surrounding the rear face and the side face of the display, a plurality of antennas disposed between the opaque region of the window plate and the first face of the housing, and a wireless communication module electrically coupled to the plurality of antennas and supporting ultra-wideband communication by using the plurality of

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/0414** (2013.01); **H01Q 1/243** (2013.01); **H01Q 3/34** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 21/205** (2013.01)





US012627060B2

(12) **United States Patent**
Navsariwala

(10) **Patent No.:** **US 12,627,060 B2**
(45) **Date of Patent:** **May 12, 2026**

(54) **LOW-PROFILE ANTENNA FOR
BELOW-GRADE APPLICATIONS**

(71) Applicant: **PCTEL, Inc.**, Bloomington, IL (US)
(72) Inventor: **Umesh Navsariwala**, Bartlett, IL (US)
(73) Assignee: **PCTEL, INC.**, Bloomington, IL (US)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 146 days.

(21) Appl. No.: **18/367,031**

(22) Filed: **Sep. 12, 2023**

(65) **Prior Publication Data**
US 2024/0097338 A1 Mar. 21, 2024

Related U.S. Application Data

(60) Provisional application No. 63/406,893, filed on Sep. 15, 2022.

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/22 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01); **H01Q 1/2283** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 1/2283; H01Q 9/40; H01Q 1/40; H01Q 1/2233; H01Q 1/04
See application file for complete search history.

(56) **References Cited**

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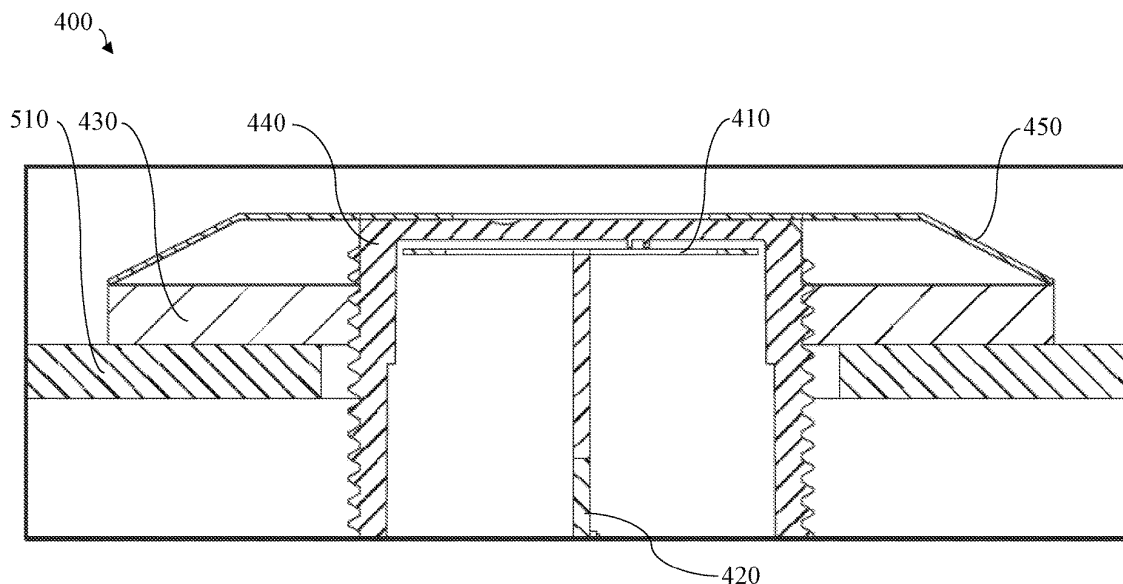
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(57) **ABSTRACT**

A capacitively coupled below-grade antenna is provided. The antenna includes a housing; a cap detachable from the housing, the cap having a top surface; a feeding element coupled to a radio module; and a radiating element provided on the cap along the top surface such that the radiating element is capacitively coupled with the feeding element.

14 Claims, 7 Drawing Sheets





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(12) **United States Patent**
Wu et al.

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(54) **ANTENNA MODULE WITH DIFFERENT
TYPE ANTENNA AND ELECTRONIC
DEVICE EMPLOYING ANTENNA**

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CPC **H01Q 21/28** (2013.01); **H01Q 9/0421**
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(58) **Field of Classification Search**
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See application file for complete search history.

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(57) **ABSTRACT**

An antenna module using two antennas with different radiation mechanisms for signal transmitting and receiving includes a substrate, a first antenna, and a second antenna. A first surface of the substrate includes a first clearance area and a second clearance area, the first clearance area is located in a first corner area of the first surface, and the second clearance area is located in a second corner area of the first surface. The first antenna includes a first radiation portion located in the first clearance area, and the second antenna includes a second radiation portion located in the second clearance area. An antenna type of the first antenna is different from an antenna type of the second antenna, and the first antenna and the second antenna are configured to transmit and receive signals of the same frequency. An electronic device is also disclosed.

18 Claims, 9 Drawing Sheets

